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Pollution Prevention in Shipboard Operations

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Introduction

The Pollution Prevention (P2) Afloat Program was established in 1995 to develop HM-related pollution prevention strategies for the U.S. Navy Fleet. Executive Order (EO) 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*, requires Federal agencies to comply with the planning and reporting provisions of the *Emergency Planning and Community Right-To-Know Act (EPCRA)*, and the *Pollution Prevention Act of 1990*. Part of Naval facility compliance is accomplished by setting goals for reducing the release of and off-site transfers of toxic chemicals for treatment and disposal by 50%, from a 1994 baseline. While Navy ships are not regarded as hazardous waste "generators" and are not required to comply with EO 12856, between 50 to 80% of hazardous waste reported by Navy homeport facilities is HM offloaded from ships. To support the shore facilities' reduction mandates, the P2 Afloat Program determines and implements HM source reduction initiatives, process or equipment changes, and recycling or reuse programs onboard ships.

The functionality and success of the P2 Afloat Program is derived from the participation of many Navy Commands and activities. The Chief of Naval Operations, Environmental Protection, Safety, and Occupational Health Division (CNO N45) provides program policy and oversight to the Program. NAVSEA 03L1 is the P2 Afloat Equipment Lifecycle Manager, providing technical engineering guidance and approval for Navy-wide implementation of P2 Afloat technology. NAVSEA 03R16 is the Research Development, Test and Evaluation (RDT&E) Program Manager and sponsors the test and evaluation of P2 Afloat equipment. The financial sponsorship of these codes, as well as funding received from Commander in Chief, Atlantic Fleet (CINCLANTFLT) Environmental Department (N465), via Naval Base Norfolk's Environmental Department, is vital to the successful testing of so many Opportunities on such a broad range of platforms.

CDNSWC Code 632 provides the technical leadership required to execute the Navy's P2 Afloat Program. They are the primary selectors of the waste streams to be targeted and the shipboard maintenance practices that can benefit from pollution prevention initiatives. They select the equipment to handle or eliminate the waste stream or process, and participate in ship checks, and equipment installation and implementation. Code 632 is also responsible for developing appropriate databases or spreadsheets, interim and final reports, and providing other technical support for the Program. CDNSWC Code 9152, as the Alteration Installation Team (AIT), has been the sole installing activity, and Naval Air Warfare Center, Lakehurst (NAWCADLKE) has been the primary procurement activity for the Program.

The information presented here provides the P2 Afloat Team's perspective on challenges encountered during the past three years, how the Team managed and corrected these issues; and the effects of the installed P2 Afloat equipment on shipboard operations. COTS products may not be the answer to all HM reduction issues but their direct shipboard applicability cannot be taken for granted. Applying common sense, low-level reengineering, and straightforward, realtime testing of COTS products are the keys to reduced installation time, operational costs, and the time allocated to accomplish standard maintenance. The most important lessons learned have been the recognition that even unsuccessful COTS products provide information to be applied to subsequent platforms. The Team recognizes that each ship is unique in design, mission and daily operational requirements, despite Class designation. Each ship requires analysis not only of the installed engineering systems, but of the human operational and management practices in place onboard. The successful installation and application of any new equipment requires an understanding of standard and hull-specific shipboard operations. The P2 Afloat Team has augmented its knowledge of ships and environmental challenges by seeking out and attaining this understanding during all stages of a ship's involvement in the Program, and the test platforms and the Team members have profited experientially.

The P2 Afloat Program

In 1995, CDNSWC Code 632 was tasked to investigate and find solutions for excess/used HM issues aboard U.S. Navy ships. Five ships were selected as prototype platforms to represent major classes in the fleet: USS ANCHORAGE (LSD 36); USS JOHN HANCOCK (DDG 981); USS CARL VINSON (CVN 70); USS GEORGE WASHINGTON (CVN 73); and USS WASP (LHD 1). Later, five more ships were added, including: USS ARCTIC (AOE 8); USS KEARSARGE (LHD 3); USS YORKTOWN (CG 48); USS RUSHMORE (LSD 47) (in place of LSD 36); and SPRUCE BARGE (YFNX 42).

For each ship, the P2 Afloat Team examined offloaded excess/used HM records and then onboard pollution prevention practices that would provide the tools to reduce, recycle, or reuse HM. These practices are called "Opportunities" and include equipment, material, and/or process changes that minimize shipboard use, procurement, storage, handling, and offload of HM. Ultimately, Opportunities that pass shipboard testing and evaluation, based primarily on a positive ROI analysis, will be transitioned to the entire Fleet.

The P2 Afloat Team's focus is on the direct use or minimal reengineering of COTS products as the means to timely reduction of shipboard hazardous material use and its associated shoreside disposal impacts. This allows for cost savings derived from conducting T&E compared to a full research and development effort, and improves turnaround time for onboard installation. The equipment must be durable, user-friendly, have proper ship interfaces, and conform to the space available on any ship. The COTS approach places much confidence in an industry perhaps wholly unfamiliar with naval applications and encourages the surface Navy to realize that what works on shore may also be viable shipboard. This concept is the heart of the P2 Afloat Program and shipboard T&E has proved the validity of this approach.

Researching HM Use and Reduction Tools

Research includes regularly identifying used and excess HM offloaded from ships, conducting equipment searches, and performing ship checks to determine and alleviate the HM requirements. Any potential reengineering of selected COTS equipment for each installation must also be evaluated. For the P2 Afloat Program, the benefit of staggered installations has permitted lessons learned to be applied to successive ships and installations, and the testing phase has provided enough time to research and remedy problems while the prototype ships are still under the umbrella of the Program.

The best tools for identifying target waste streams are data logs from Naval shore facilities. The Norfolk Naval Base and Naval Station San Diego HM offload data reports supply quantitative breakdowns on ships' waste streams, listing all HM offloaded by ships—providing direct ties to our primary HM elimination and reduction targets. In addition, the homeport environmental personnel provide insight on which waste streams have high volume or cost concerns. Most P2 Opportunities are aimed at reducing the large amounts of paint, oily rag, and solvent wastes identified in the offload reports and by shore environmental personnel.

The P2 Afloat Team has also researched the HM used in periodic shipboard maintenance. As the Program matures and Opportunities transition, HM will be eliminated from shipboard use and the supply system, mandating changes to Planned Maintenance System (PMS) documentation. This must be accomplished as P2 processes are implemented Fleet-wide to ensure correct application of the HM reduction tools provided.

Shipboard assessments are another important step towards the successful integration of P2 Afloat equipment selection and installation. The assessment team is composed of engineers who examine ships' Departments and the associated maintenance processes which generate or influence excess or used HM. During the assessment, interviewing the deckplate-level sailor provides a unique perspective on shipboard problems. Interviews with work center personnel help the P2 Afloat Team identify ship specific requirements, as sailors are able to describe the most hazardous maintenance tasks, best explain and demonstrate PMS requirements, and offer valuable ideas for correcting HM issues. Different coasts and operational areas also affect the operations of a ship. An east coast ship may have different inport and underway restrictions than a west coast ship. Different shore facilities also have different local regulations, support capabilities and infrastructures that affect ships' inport operations.

Working with COTS products presents other unique issues, most obvious are the loss of control over design specifications and the requirement to work with equipment as it was designed for a completely different environment and user group. Researching COTS products requires indepth knowledge of the specific onboard application and installation location. To this end, and especially during the test and evaluation phase, ship checks should be accomplished prior to equipment procurement.

Other important lessons stem from the onboard interface restrictions that accompany retrofitting in-service ships. Finding equipment that supports a P2 Opportunity, interfaces with ship services, and

fits into spaces onboard narrows the field of selection. Some ships prefer pneumatic vice electric tools and equipment, further restricting the options available. Selection of the vacuum cleaners is a perfect example of the pneumatic or electric decision being made for the ships. The limitations of an individual ship's services must be acknowledged and accounted for when selecting equipment. Water and air connections must be evaluated and the appropriate hoses and fittings supplied if not available onboard. Ship requirements differ, even on ships within the same class, contradicting the idea of "cookie cutter" installations and applications. Ship checks on all relevant classes are, therefore, critical to the success of the program.

For equipment to be selected to support a P2 Opportunity it must, at a minimum, accommodate cost limitations, weight and space requirements, and installation feasibility. Disassembling a large piece of equipment so it fits through a 26-inch by 66-inch hatch continues to be a challenge. Few pieces of large commercial equipment are shipped in segments that will fit through an opening of this size. In such instances, having the manufacturer reengineer a piece of equipment for disassembly is mandatory. Fortunately, many manufacturers of specialty items have volunteered to reengineer certain aspects of the equipment to better suit a shipboard environment. For example, the wheelbase of the pneumatic vacuum cleaner was redesigned with a broader platform and wider wheels to make the system more stable when moved around ship decks.

Procurement and Logistics

Despite the rapid pace of the P2 Afloat Program implementation, significant thought, consideration, and effort has been devoted to the procurement aspects of the program. Most procurement is conducted through another Warfare Center, mandating thorough and succinct communications with the purchaser. The procurement process should begin at least three months before the installation. This provides sufficient time to identify distributors, obtain and compare cost estimates, and accommodate the legal constraints required prior to equipment purchase and any extensive manufacturing lead times.

During the test and evaluation phase, spares, consumables and technical literature for all P2 equipment have been provided at installation. During a six-month deployment, the Department owning the space or equipment may have to service the equipment and spare parts must be available, especially those most susceptible to failure with intense use over a short time. Belts, hoses, filters, and hose connections are likely to be damaged, misplaced, or expended by use. Anticipated failures must be supported while considering storage constraints on ships. The Program supports a prototype ship for 18 months, typically including a six-month deployment. User feedback has led to the development of a thorough and accurate spares and consumables list for all equipment, in the event a ship has to procure a repair part while deployed. After the deployment and return of five P2 ships and the examination of maintenance records, the P2 Team has been able to identify many of the parts that must be onboard and included in the final logistics package.

Copies of the manufacturer's technical literature are also provided to the ship's P2 Afloat point of contact and placed in the space with the associated P2 equipment. Recommended use and logistics data for spares are included in the data package. Sailors are encouraged to read the technical information, P2-specific requirements, and follow all provided instructions. For the six to 18 months

following installation, this may be the only maintenance documentation available to ship's force. As the equipment being provided is new to the Navy, ship's force needs to take the initiative to read the manual carefully and become more familiar with the maintenance requirements for each piece of equipment. To alleviate this problem, the Program has always provided extensive training at the onset of the test and evaluation phase, and follow-on training, as requested.

Installation

Having an Alteration and Installation Team (AIT) that is familiar with the P2 Afloat objectives and equipment has decreased installation time by minimizing the learning curve. Because many of the AIT members have worked in or with the Navy for many years and are experts in Hull, Mechanical & Electrical (HM&E) systems and their associated maintenance requirements, their input regarding P2 installations is invaluable. As a fast-paced shipboard T&E program, new challenges are constantly encountered, whether with shipboard interfaces, equipment design, or any other number of issues, requiring flexibility and last minute changes. In addition, the AIT's oversight and input helps to ensure that all installation procedures meet the General Specifications for Shipbuilding and other legal requirements.

Many of the lessons learned are common sense for those who spend time aboard ships and others have come to light as a result of this non-traditional program. Installing equipment for the first time can affect the entire installation schedule if specialists have to work overtime to accommodate an unusual or unexpected requirement. To alleviate unexpected issues, equipment documentation is provided to the AIT before the installation. The installation team must have the time to review equipment requirements and perform a ship check to get an idea of what the installation involves. This also provides the installation team adequate time to select the right materials for the job, as well as time to prefabricate foundations.

Post-Installation T&E and ROI Analyses

The results of shipboard testing and evaluation are primary factors in determining whether any equipment is transitioned to the Fleet. From the inception of the Opportunity to this point, the P2 Afloat Team has been involved in research, procurement, and installation activities, but beyond installation the success of an Opportunity lies with ship's force. Currently, there are 27 Opportunities being tested and evaluated on six classes of Navy ships targeting a variety of ships' waste streams. These items are listed in Table 1. At the same time, new Opportunities are being tested, including Rechargeable Batteries, Reusable Oil Filters, and Low-Mercury Fluorescent Lamps.

Logsheets requesting information specific to an Opportunity are delivered with each piece of P2 equipment. Data including date of use, comments, and other information are recorded on the logsheets. An assessment of the baseline maintenance processes, as compared to an estimate of the time saved by the new process or tool, is also required. If spares are provided, a logsheet to record parts replacement data is included. During P2 equipment training, sailors are asked to log in the requested information, and the importance of the data is emphasized. Without accurate use and maintenance data, it is difficult, if not impossible, to quantify the effectiveness of the any equipment.

As there are no standard PMS requirements associated with the equipment, data collection depends on individuals and the Commands now responsible for the equipment.

• Aqueous Parts Washers	• Backpack Vacuums	• Cable Cleaners & Lubricators
• Drum Crusher/In-Drum Compactors	• Mercury Ion Exchange Cartridge	• Thermoset Powder Coating System
• Glycol Recycler	• HVLP Paint Guns	• Hydraulic Fluid Purifier
• Maintenance-Free Batteries	• Explosion-Proof Vacuums	• Vortex Component Cooler Gun
• Paint Brush Holders	• Particle Counter System	• Paint Gun Cleaning Station
• Paint Tinting System	• Rag Recycling System	• Photoluminescent Labels
• Pressure Washer	• Paint Dispensers	• Hand Pumps & Spray Bottles
• Solvent Recycling Unit	• Flashpoint Tester	• Reciprocating Saw
• Vacuum Sanding Systems	• Wet/Dry Vacuums	• Paint Pens

TABLE 1. P2 Afloat Equipment

Specific and accurate usage data must be entered regularly for the logsheets to be useful. Typically, the more enthusiastic the ship is about the equipment, the better the response. Logsheet data for portable equipment, such as the Vacuum Cleaners, Reciprocating Saw, and Pressure Washers are often non-existent. Return on investment analyses for these pieces of equipment must rely on qualitative data based on user interviews and data reported verbally in place of specific logsheet data. In addition, it has been confirmed that sailors do not log data each time the equipment is used.

Usage data alone do not warrant or discount the effectiveness of any equipment. Reductions in manhours, maintenance periodicity, HM inventory, and improved quality of life are all viable components of the decision to transition any piece of P2 equipment to the Fleet. The east and west coast "Smart Ships" are both involved in the P2 Afloat initiative. Their goal of decreased manning concurs with a P2 Afloat Program goal to reduce the time spent on shipboard maintenance activities. Unfortunately, reduced manning onboard Smart Ships provides less time for ship's force to update logsheets. In these circumstances, qualitative data is weighed more heavily to supplement the lost value of logsheet data. To assist ship's force, automatic data systems (such as hour-counter meters on electric equipment) have been implemented.

Following the installation of the P2 suite of equipment and the subsequent deployment T&E phase, a final report providing the results and cost analyses of P2 initiatives tested and evaluated onboard is developed for each prototype ship. The report recommends transitioning Opportunities that are technically and economically feasible, and compatible with ship operations. Again, the initial decision for transitioning P2 equipment relies on data entered on logsheets during a ship's deployment. Misrepresentation of data input on the logsheets or neglecting to regularly log

equipment use could mean the failure of a P2 Opportunity. However, there are Opportunities that the engineers and the P2 Team recognize as vital to the reduction of HM onboard, the improved safety of the sailor, and a reduced time applied to a maintenance process that may not be reflected in a formal ROI. Engineering judgment and qualitative input from ship's force are often called upon to augment the decision to transition any P2 equipment or process.

Transitioning P2 Afloat Equipment

The ultimate product of the P2 Afloat Team's efforts will be the Fleet-wide transition of all equipment coming through the T&E phase with a favorable ROI. Opportunities whose initial ROI did not make the cut but may have great potential for preventing pollution were recommended for further test and evaluation. If an Opportunity shows negative cost savings, had a break-even point much greater than three years, or was not effective when compared to the baseline process, it is not recommended for transition.

Transition will be accomplished in two parts. A Jump-Start implementation phase will begin in FY99 and the actual Fleet-wide transition will commence in FY00 and continue through FY05. During Jump-Start, a group of ships from a variety of classes will receive 11 of the 23 pieces of equipment planned to be transitioned. Jump-Start will provide a final T&E opportunity for the P2 Afloat Team and the AIT to fill in any information, procurement, or engineering gaps prior to Transition. Ships represented in the Jump -Start and T&E phases will receive the balance of the equipment during the transition phase. The Transition phase will affect most ships of the current Fleet. The P2 Afloat Team is working in concert with the current ship acquisition programs, including LPD 17, DD 21, and CVX to ensure that the P2 Afloat equipment is provided if still required, based on new maintenance and inventory practices.

One of the most critical elements of the transition phases will be the completion of the formal logistics packages to support the P2 Afloat equipment. PMS documentation will be finalized during the early part of the transition period as well. Teams from CDNSWC Code 631 and NSWCCD-SSES Code 915 will be instrumental in the delivery of all of the requisite logistic information. In addition, Code 631 will represent the P2 Afloat Program as the equipment In-Service Engineering Agent.

Conclusion

Successful program implementation is and will continue to be a product of broadbased experience, shipboard test and evaluation, deckplate analysis, appropriate application of commercial products, and accurate assessment of transition targets. The P2 Afloat Program is an alternative to the traditional Navy approach of ship-specific research and development, and successfully brings together the effective handling of smaller budgets with the use of exceptional commercial industry products in the shipboard arena. Currently, 27 Opportunities are installed on six ships representing five ship classes. The P2 equipment suite will continuously be updated and evaluated during shipboard assessments, and equipment that proves effective and economically viable will be transitioned to the Fleet—bringing research to reality.

Authors

Rita Schuh is an environmental engineer and member of the Pollution Prevention Afloat Team. Previously, she was the Pollution Prevention Manager at Naval Station San Diego for both ashore and afloat hazardous and solid waste; the Hazardous Waste Manager at Misawa Air Base in Japan; and conducted Installation Restoration efforts at installations in the Naval Facilities Engineering Command, Chesapeake Division. Mrs. Schuh earned her BS in Mechanical Engineering from Ohio State University and her Masters in Public Administration from the University of Oklahoma.

Robin Hays began working at CDNSWC Code 632 as a member of the P2 Afloat Team in 1997. She has over ten years experience with naval environmental initiatives, engineering, and logistics in support of NAVSEA, NAVSUP, and CNO codes. As a member of the P2 Afloat Team, Ms. Hays has managed P2 equipment installations and coordinated logistics requirements for P2 ships currently in the T&E phase. Her primary tasks in the P2 Afloat Program include participation in ship assessments, logistics coordination, outyear planning, and documentation development. She is also the Team's POC for new acquisition programs.